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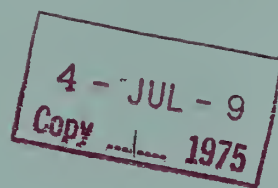
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Electrical Hazards in Underground Bituminous Coal Mines



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Electrical Hazards in Underground Bituminous Coal Mines

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ELECTRICAL HAZARDS IN UNDERGROUND BITUMINOUS COAL MINES

by

W. A. Mason¹

ABSTRACT

An investigation of 1,404 injuries related to electricity in underground bituminous coal mines revealed that more than 96 percent of all electrical accidents were caused by (1) arcs resulting in burns, (2) electrically generated heat resulting in burns and scalds, and (3) electrocution and shock. Data analysis indicates that a reduction in electrical accidents is immediately possible by reducing defective splices and insulation breaks and by proper placement of trolley poles. Sixty-six percent of the mine fires investigated by the Bureau of Mines through 1972 and 21 percent of all methane ignitions can be attributed to electrical ignition sources and inadequate design of electrical equipment used in the mining environment.

INTRODUCTION

The investigations and recommendations for the Electrical Hazards Study were made during the first half of 1973 and updated in 1974. The data used in the initial study were from electrical accidents which occurred in 1972. The update incorporated the electrical accident data for 1973.

For the purposes of this study, electrical hazards have been divided into two broad categories--accidents that caused injuries to the body and those that cause fires. The nature of the bodily injury is classified as to its principal physical characteristics, such as electrical arcs (radiation burn), electrical burns (heat), shock, and electrocution, etc. Fires are classified by the ignition source, such as electrical arcs, short circuits, overloads, etc. The accident and injury information in the Health and Safety Analysis Center data base was examined to determine which types of electrical accidents should receive maximum attention for this study.

DISCUSSION

A study of 1,404 accident and injury reports for the years 1972 and 1973 revealed that more than 96 percent of all electrical accidents resulted from electrical arcs, electrically generated heat, and electrocution and shock

¹Electronics engineer.

(table 1). From an analysis of the data, it was concluded that electrical arcs and burns showed the most promise for reduction in electrical accidents.

TABLE 1. - Electrical accidents and injuries, 1972 and 1973

Description	1972		1973	
	Number	Percent	Number	Percent
Electrical arcs.....	242	37.35	156	20.63
Electrical burns.....	276	42.60	452	59.79
Burns (heat).....	56	8.64	72	9.52
Electrocution and shock..	49	7.56	53	7.01
Puncture.....	9	1.38	0	0
Chemical burn.....	6	0.93	4	0.53
Contusion.....	3	0.46	4	0.53
Sprain or strain.....	2	0.31	6	0.79
Multiple injuries.....	1	0.15	8	1.06
Unclassified.....	4	0.62	1	0.14
	¹ 648	100.00	² 756	100.00

¹Represents a 63.84 percent sampling of all electrical accidents for 1972.

²Represents a 100 percent sampling of all electrical accidents for 1973.

Field investigations have shown that cables and trolleys are the greatest concern of mine operators. The information in the data base is in agreement with the findings of the field investigations (table 2). The greatest problems with cables are defective splices, and breaks in the insulation. These defects are usually detected when handling the cable, resulting in a shock or an arc which burns the hands or eyes. The hands and eyes are the parts of the body most commonly injured in an electrical accident (table 3).

TABLE 2. - Main causes of electrical arcs and burns

Cause	1972		1973	
	Number	Percent	Number	Percent
Cables.....	155	29.92	197	32.40
Trolleys.....	81	15.64	94	15.46
Switches.....	58	11.20	80	13.16
Haulage equipment.....	35	6.76	60	9.87
Electrical apparatus.....	25	4.83	31	5.10
Power and lighting circuits	18	3.47	21	3.45
Mining machinery.....	15	2.90	31	5.10
All other.....	131	25.28	94	15.46
	518	100.00	608	100.00

TABLE 3. - Part of body injured due to electrical
accident--1973

Part of body	Number	Percent
Eyes.....	256	33.86
Hands.....	206	27.25
Multiple major body parts (for example, arm and leg).....	103	13.62
Fingers.....	36	4.76
Body system (for example, nerve centers).....	31	4.10
Face.....	27	3.57
Wrist.....	11	1.46
Back, chest and shoulders.....	10	1.32
Ears.....	7	0.93
All other.....	69	9.13
	756	100.00

Trolleys are the second largest cause of arcs and burns. This type of injury generally occurs when hanging nips or placing the trolley pole on the trolley. In both of these instances the injury is caused by not shutting off the equipment prior to connecting it to the trolley. The arc is created from the current drawn by the energized equipment.

Another hazard associated with trolleys is the possibility of mine fires caused by overheated trolley wires. High resistance faults that do not draw enough current to trip the circuit breaker can develop on the wires and cause them to overheat. Under this condition, the heat generated could be enough to soften the wire and cause the trolley to fall. If it falls on coal or other combustible material, a fire may result.

A substantial number of mine fires are caused by electrical sources. Sixty-six percent of the mine fires investigated by the Bureau of Mines through 1972 were due to electrical arcs, shorts, and overloads (table 4). However, there has been a significant reduction in mine fires in recent years, particularly since the passage of the Coal Mine Health and Safety Act.

TABLE 4. - Record of underground coal mine fires investigated by the Bureau of Mines in the United States since July 1952

Year	Arcing and electrical shorts	Electrical overload	Friction	Spontaneous	Other	Total
1952	5	0	3	2	4	14
1953	16	4	0	4	9	33
1954	24	2	7	4	9	46
1955	26	2	3	8	8	47
1956	27	1	7	5	3	43
1957	40	2	5	5	9	61
1958	41	3	10	4	4	62
1959	34	6	3	3	5	51
1960	38	5	7	4	12	66
1961	32	3	13	2	11	61
1962	21	3	3	1	12	40
1963	40	3	8	6	7	64
1964	37	3	4	0	8	52
1965	38	2	4	1	11	56
1966	30	0	6	2	3	41
1967	33	3	6	3	4	49
1968	34	0	1	7	7	49
1969	38	2	6	1	5	52
1970	13	2	5	0	11	31
1971	5	0	1	2	3	11
1972	6	1	0	4	6	17
	578	47	102	68	151	946

Methane ignitions can be related to electrical sources (table 5). A minimum of 21 percent of all methane ignitions can be directly attributed to electrical ignition sources. One area of possible ignitions is that of intermachine arcing in alternating current equipment. This problem has been thoroughly investigated by Krek and Wolf of MESA.² A report of their work has been circulated in MESA and the Bureau of Mines. It describes the measurement and test procedures for reducing intermachine arcing.

²R. I. Krek, R. A. Wolf. Intermachine Arcing Resulting From Induced Voltages in AC Mining Equipment. (MESA informal report available from Pittsburgh Technical Support Center, 4800 Forbes Ave., Pittsburgh, PA 15213.)

TABLE 5. - Methane ignition sources in the Nation's coal mines
versus number of miners killed or injured
July 1952 through December 1968

Ignition source	Number of ignitions and explosions	Number injured	Killed
Explosives.....	43	63	44
Electrical equipment (either nonpermissible or in non- permissible condition.....	52	88	43
Smoking and open flames.....	55	46	13
Locomotives.....	22	18	10
Trailing cables.....	21	18	9
Flame safety lamp.....	17	25	5
Miner bits.....	156	141	3
Multiple source.....	13	19	135
Not determined.....	15	14	83
Miscellaneous.....	55	58	60
No data available.....	1	4	0
	450	494	405

CONCLUSIONS AND RECOMMENDATIONS

Most of the problems in electrical accidents stem from deficiencies in the design of electrical equipment used in the mining environment. The results of this study warrant the following recommendations:

1. For shocks, burns, and arcs due to trailing cables, it is recommended that the use of cables with circuit conductor shields, such as the SHD-GC, be investigated for installation on all trailing cable machinery. A contract to evaluate the use of circuit conductor shields is currently underway at the Pennsylvania State University under the Coal Mine Health and Safety Research Program.

2. A speedy reduction of accidents associated with arcs and flashes from trolleys can be achieved through training, in the form of safety films and courses. A film on the electrical hazards has been subsequently prepared by MESA's Education and Training activity.

A second method to reduce accidents would be to provide an interlocking circuit which would prevent the equipment from drawing current after power was lost until it was manually reset.

3. The problem of overheated trolleys caused by low current overloads can be reduced by the use of "rate of rise" circuit breakers. These breakers sense the difference between a short circuit and a momentary line surge from normal equipment operation. In addition, long term currents caused by low current overloads can be detected and the circuit removed from the power source. Further work must be done to determine the effectiveness of these breakers for mine operations.

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